

# Epidemiological Analysis of Echinococcosis Morbidity and Investigation of the Infection Rate and Role of Murine Rodents in the Spread of Alveococcosis in the Territories of Kara-Kulzhinsky and Chon-Alai Districts of the Osh Region

Kursanbek M Raimkulov<sup>1,\*</sup>, Baken K Sharsheeva<sup>2</sup>, Zhazgul S Sabytbekova<sup>1</sup>, Adina Zh Zhekshenbekova<sup>2</sup>, Vera S Toigombaeva<sup>1</sup>, Omurbek T Kuttubaev<sup>1</sup>

<sup>1</sup>Kyrgyz State Medical Academy named after I.K. Akhunbaev, Bishkek, Kyrgyz Republic

<sup>2</sup>Kyrgyz National University named after Zhusup Balasagyn, Kyrgyzstan

## ABSTRACT

The article provides data from an epidemiological analysis of the incidence of cystic echinococcosis (CE) among the population of the Kyrgyz Republic for the period from 1986 to 2022. A long-term trend analysis of the incidence revealed an annual moderate growth rate of 14.5%. The spread of CE is evident, with the risk concentrated in the southern region, which accounts for 54% of the total incidence. The results of a study on the infection rates and the role of typical rodents in the spread of alveococcosis in the territories of the Kara-Kulzhinsky and Chon-Alai districts of the Osh region of the Kyrgyz Republic are also presented. During the dissection of 256 typical rodents in a locality within the Kara-Kulzhinsky district, the larval form of alveococcosis was identified in 3 animals (1.2%): 2 house mice (0.8%) and 1 common field vole (0.4%). In the dissection of 125 typical rodents from a locality in the Chon-Alai district, the larval form of alveococcosis was found in 2 house mice, accounting for 1.6%.

**Keywords:** Mouse-Like Rodents, Autopsy, Morbidity, Alveococcosis, Natural Focus, Contamination, Histological Examination.

## INTRODUCTION

CE is a disease caused by parasites in the tissues and organs of humans in the larval stage of the cestode *E. granulosus*. It is characterized by a chronic course, the formation of cysts, and destructive lesions of the liver, lungs, and other organs [1]. CE has been recognized as a public health problem since 1950 [2]. Echinococcosis is globally distributed, representing a significant burden on world health and the economy [3].

CE and alveolar echinococcosis (AE) in humans are considered priority neglected zoonotic diseases, with the WHO advocating for their control. The incidence of cystic echinococcosis in humans is estimated at 2-3 million cases worldwide. Disability-adjusted life years (DALYs) and economic losses reach 1 million (M) DALYs, or annual losses amounting

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## \*Corresponding Author

**Kursanbek M Raimkulov**

Candidate of Biological Sciences, Associate Professor of the Department of Medical Biology, Genetics and Parasitology of the Kyrgyz State Medical Academy named after I.K. Akhunbaeva. Bishkek, st. Suerkulova 3, Kyrgyz Republic, Phone: +996772424266; **E-mail:** kursanbek@mail.ru

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to 3 billion U.S. dollars (annual costs for treating people and compensation in livestock) [4].

In the last decade, there has been not only an increase in the incidence of echinococcosis but also an expansion of the geographical boundaries of the disease. In Central Asian countries, echinococcosis occurred at a rate of 2.7-14.5 cases per 100,000 populations from 2006 to 2008; in Europe, the rate was 0.14-15.8 [5,6].

In the Kyrgyz Republic, the official registration of echinococcosis began in the 1960s when the average incidence rate was 2.5 per 100,000 populations. In the 1970s, it increased to 3, in the 1980s to 3.6, in the 1990s to 8.02, and in the 2000s to 12.4 per 100,000 populations. The trend of increasing morbidity from echinococcosis continues into the 21st century [7].

The incidence of echinococcosis has significantly increased over the past 30 years in Kyrgyzstan and continues to pose a serious medical and social problem in the Kyrgyz Republic. Its relevance is underscored by the lack of a trend towards a decrease in the number of patients and the existence of endemic regions, where the incidence rate varies from 3.6 to 21.2 per 100,000 populations [8].

As the authors note [9], a total of 10,093 patients examined in Osh, Naryn and Batken regions were diagnosed with cystic echinococcosis for the first time, and postoperative cases ranged from 0.2 to 25.2% in the studied regions. Typical factors such as dog or livestock ownership had little effect on the risk of CE (odds ratio [OR] = 1.18-1.83).

In connection with the above, the aim of this study is to investigate the infestation and role of murine rodents in the spread of alveococcosis in the territories of the Kara-Kulzhinsky and Chon-Alai districts of the Osh region of the Kyrgyz Republic, with the goal of establishing natural and synanthropic foci of alveococcosis in the studied areas.

## MATERIALS AND METHODS

To conduct an epidemiological analysis of human echinococcosis infection parameters in the Kyrgyz Republic, data from state statistics, annual reporting forms № 1 ('Report on Infectious and Parasitic Diseases'), primary materials from epidemiological investigations, and form No. 18 ('Report on the Activities of the Center for State Sanitary

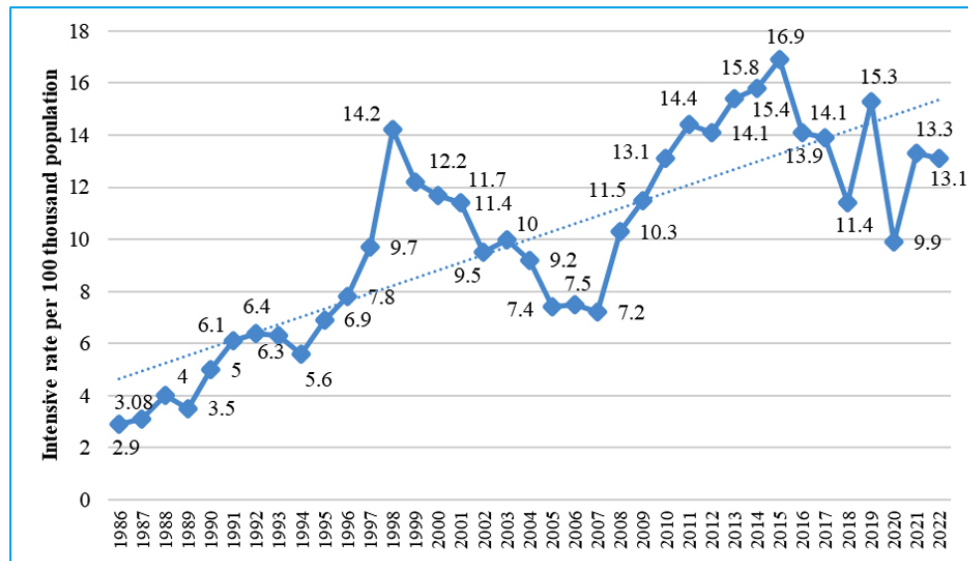
and Epidemiological Surveillance (Disinfection Station) of the Department of Disease Prevention and State Sanitary and Epidemiological Surveillance of the Ministry of Health of the Kyrgyz Republic (DDPSES MOH KR)') were analyzed and subjected to statistical processing. Additionally, medical histories of individuals with echinococcosis in the regions of the republic, as well as the results of the authors' own research, were examined. During the study period, post-operative patients were registered for follow-up. The material for the study consisted of our own zoological samples (captured small wild and synanthropic murine rodents). The animals were dissected on the day of capture, and pieces of their organs (liver, lungs, spleen, heart, pancreas) were fixed in alcohol and subsequently examined in a stationary laboratory [10]. A total of 381 small mammals were captured and dissected, of which 256 specimens (including: common field vole - 172, common shrew (blind mole) - 38, house mouse - 26, and silver field vole - 20) were from the Kara-Kulzhinsky district, and 125 (including: common field vole - 60, common shrew (blind mole) - 22, house mouse - 28, and silver field vole - 15) were from the Chon-Alai district.

## Research Methods

The trapping of rodents and their dissection were carried out in accordance with the methodological guidelines for zoological work [10], while the preparation of histological specimens for light and electron microscopy followed the techniques outlined in the tutorial edited by N.A. Yurina and A.I. Radostina [11]. The determination of the species composition of the captured animals was conducted using the key by I.M. Gromov and A.I. Yanushovich [12]. In laboratory conditions, all internal organs were studied using morphological and histological research methods.

## RESULTS

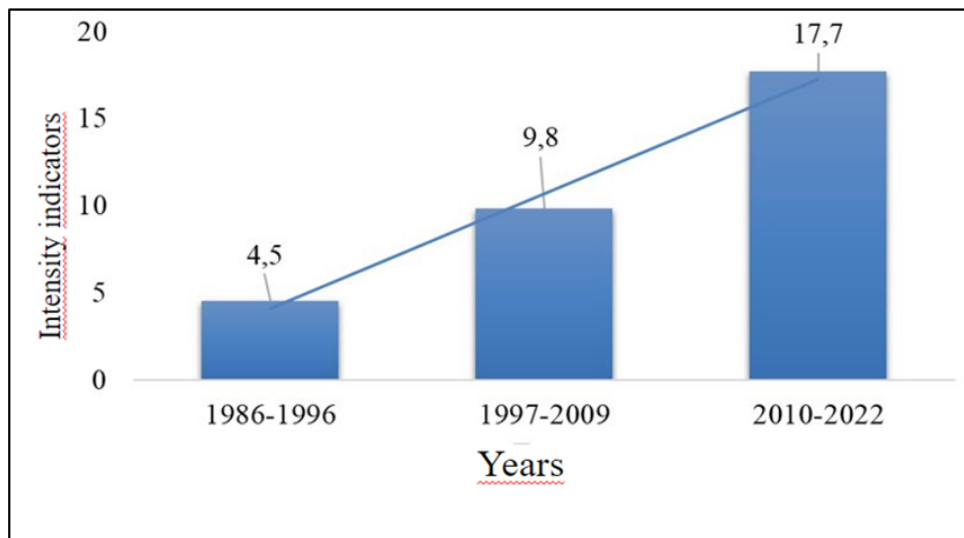
Throughout the entire observation period, there has been a moderate upward trend in the incidence of echinococcosis among the population of the republic, with an annual growth rate of 14.5%. During the analyzed period, echinococcosis transitioned from being a rarely encountered helminthiasis to a group of widespread parasitic diseases, with the intensity of the incidence in 2022 increasing by 4.5 times compared to 1986, and the territory of the republic has acquired endemic status (Figure 1).



**Figure 1.** Long-term dynamics of the incidence of echinococcosis in the population of the Kyrgyz Republic for the period 1986-2022.

The territorial distribution of echinococcosis is widespread with varying proportions across the regions of the republic. More than half of the reported cases of echinococcosis occur in the southern region - 54%.

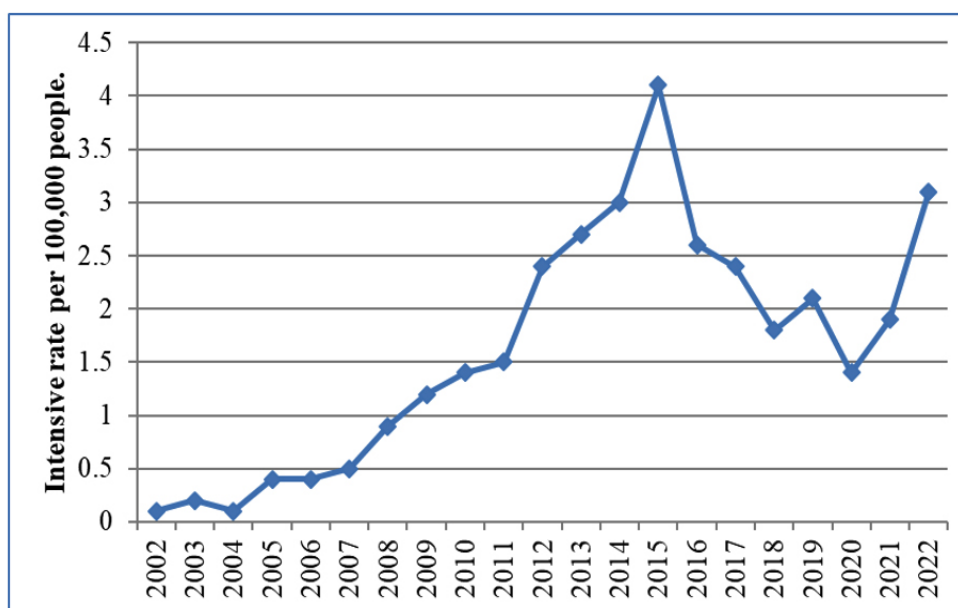
For the analyzed period (1986-2022), the first 11 years (1986-1996), which coincided with the final years of the Soviet Union, the establishment of the republic's independence, and the prioritization of animal husbandry, showed a low average intensity of incidence at 4.50 per 100,000. In the following 13 years (1997-2009), during the period of the formation of private livestock farms and private veterinary services, the average incidence rate increased 2.1 times, reaching 9.8 per 100,000. Due to the paid veterinary service, the average intensive indicator increased in comparison with the previous indicator by another 1.8 times, and with the initial indicator by 3.9 times (Figure 2).



**Figure 2.** Dynamics of indicators of the incidence of echinococcosis in the population of the Kyrgyz Republic for the period 1986-2022 for time periods.

The average intensity of echinococcosis incidence per 100,000 populations in the districts of the Osh region during the study period is as follows: Alai district - 40.8, Kara-Kulzhinsky and Chon-Alai districts - 26.1 each, Aravan district - 15.7, Kara-Suu district - 15.3, Nookat district - 13.8, Uzgen district - 13.3, and Osh city - 9.3. In the Kara-Kulzhinsky district, the average long-term incidence rate of CE per 100,000 populations was  $18.1 \pm 2.7$ , with a minimum of 3.4 in 2007. For AE in the Kara-Kulzhinsky district, the average long-term incidence rate was 2.0 in 2020, with a maximum of 43.2 in 2014 and 5.7 in 2016, respectively.

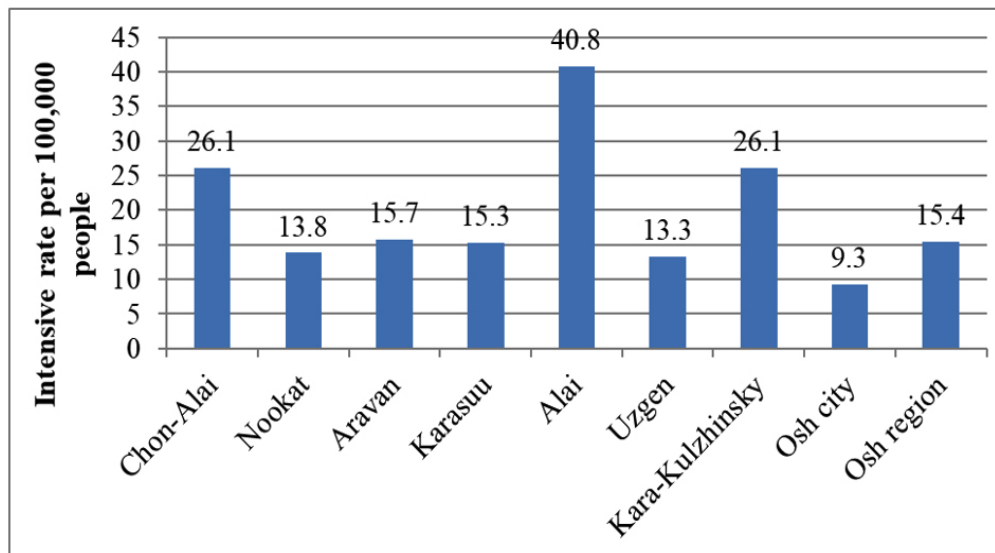
During the period from 2005 to 2013, the incidence of echinococcosis increased more than threefold (3.2) compared to the preceding twenty-year period, and from 2014 to 2022, it increased more than once (1.2). Compared to 2005, the incidence in 2022 increased more than one and a half times (1.9). In comparison to 2005, the incidence of alveococcosis in 2022 increased more than 2.5 times. Alveococcosis has shown an overall increasing trend in the republic since 2011: in 2012, it increased by 2.0 times, and in 2022, by 2.5 times (Figure 3).



**Figure 3.** Long-term dynamics of the incidence of AE in the population of the Kyrgyz Republic for the period 2002-2022.

Retrospective data indicate an unfavorable epizootiological situation regarding echinococcosis and alveococcosis in the Kara-Kulzhinsky district of the Osh region. Therefore, we conducted a retrospective analysis of the residents in the districts of the Osh region, using the Chon-Alai district as an example, from 2000 to 2022 to study the degree and frequency of echinococcosis invasion in the Chon-Alai district of the Osh region, Kyrgyz Republic.

From 2000 to 2022, 158 residents of the Chon-Alai district underwent surgery for echinococcosis in surgical hospitals in the cities of Bishkek and Osh, as well as in regional hospitals in the Osh region, with an average of 10.13% being children under 14 years old. The intensity of echinococcosis incidence (IC) per 100,000 populations in the Chon-Alai district has rapidly and significantly increased since 2008. In 2000, the IC was 22.5; by 2013, it had risen to 65.0, and in 2015, it reached 87.0. During the period from 2010 to 2019, the incidence of echinococcosis increased by more than 6 times compared to the 2000-2009 period (Figure 4).



**Figure 4.** Average intensive incidence of echinococcosis by districts of the Osh region of the Kyrgyz Republic for 2000-2022 (per 100,000 population).

The average long-term intensity of echinococcosis incidence per 100,000 populations was 26.2, with a minimum of 4.1 (in 2004) and a maximum of 87.0 (in 2015). Cases of echinococcosis in the Chon-Alai district were identified in all rural administrations. However, official statistical data do not always reflect the true picture of population invasion.

During the autopsy of 256 mouse-like rodents in the settlement of the Kara-Kulzhinsky district, the larval form of alveococcosis was identified in 3 animals (1.2%): 2 house mice (0.8%) and 1 common field vole (0.4%). Of the infected house mice, one was caught in the settlement of Chalma, and the other in the settlement of Kyzyl-Zhar in the Kara-Kulzhinsky district. Additionally, a common blind mole was caught in the nearby fields of the settlement of Kyzyl-Zhar in the Kara-Kulzhinsky district (Table 1).

**Table 1.** Infestation of rodents with alveococcus in the Kara-Kulzhinsky and Chon-Alai districts of the Osh region

№	Type of animal	Number of examined rodents		Infested					
				Kara-Kulzhinsky district		Chon-Alai district		Total	
		Kara-Kulzhinsky district	Chon-Alai district	Absolute number	%	Absolute number	%	Absolute number	%
1	<i>Mus musculus</i>	26	28	2	0,8	2	1,6	4	7,4
2	<i>Common field vole</i>	172	60	1	0,4	0	0	1	0,4
3	<i>Common blind mole (common shrew)</i>	38	22	0	0	0	0	0	0
4	<i>Silver vole</i>	20	15	0	0	0	0	0	0
	<b>Total:</b>	<b>256</b>	<b>125</b>	<b>3</b>	<b>1,2</b>	<b>2</b>	<b>1,6</b>	<b>5</b>	<b>1,3</b>



During the autopsy of 125 mouse-like rodents in the settlement of the Chon-Alai district, the larval form of alveococcosis was identified in 2 house mice, which accounted for 1.6%. Of the infected house mice, one was caught in the settlement of Kashka-Suu, and the other in the settlement of Achy-Suu in the Chon-Alai district (Table 1).

In all cases, the foci of infection were localized in the livers of the animals. The detection of alveococcus cysts in the livers of house mice in the villages of Chalma and Kyzyl-Zhar in the Kara-Kulzhinsky district, as well as in the villages of Kashka-Suu and Achy-Suu in the Chon-Alai district, indicates the formation of synanthropic foci of alveococcosis in these localities. Both stray and domestic dogs can serve as definitive hosts (yard dogs).

All surveyed localities in the two districts of the Osh region are located near natural foci, and the local areas are widely used as summer pastures (jailoo), where there is a possibility of infection for stray dogs from wild mammals, which may subsequently lead to human infection with alveococcosis.

Retrospective epidemiological data indicate an unfavorable epidemiological situation regarding echinococcosis and alveococcosis in the Kara-Kulzhinsky district, especially in the localities of Chalma, Kyzyl-Zhar, as well as in the Chon-Alai district, where the problem is most pronounced in the localities of Kashka-Suu, Achy-Suu in the Osh region.

If the Osh region ranks second in terms of echinococcosis incidence in the republic after the Naryn region, then the Kara-Kulzhinsky district ranks second among the seven districts of the Osh region, while the Chon-Alai district ranks third in the prevalence of echinococcosis (Figure 4).

## DISCUSSION

A moderate increase in incidence, with an annual growth rate of 14.5%, serves as a warning signal that echinococcosis, previously considered a relatively rare helminthic disease, is becoming an increasingly widespread parasitic disease in the country.

The most notable growth in the intensity of the incidence rate, which increased 4.5 times from 1986 to 2022, indicates that previous control and prevention measures for this disease have proven insufficient. The endemicity of the territory of the republic underscores the necessity for a comprehensive approach to addressing the problem, including enhanced monitoring, preventive work among the population, and programs to control the disease in animals.

The territorial distribution of the incidence also warrants attention. More than half of the cases of echinococcosis are registered in the southern region of the country, which may be related to both the characteristics of livestock farming

in these areas and the population's traditions concerning household management and contact with animals. The data on the high level of incidence in the southern regions emphasize the necessity to focus on educational and preventive initiatives specifically in these areas to reduce morbidity.

The analysis of periods indicated that in the first 11 years of observation (1986-1996), the incidence rates remained low (4.50 per 10,000 population), which can be attributed to the economic and social changes occurring in the country during that time. However, since gaining independence and changing priorities in livestock farming, the dynamics of incidence have changed, and this helminthic disease has become a pressing issue requiring attention and resources to ensure public health.

The analysis of echinococcosis morbidity levels in various districts of the Osh region revealed noticeable differences in intensity rates and disease dynamics. According to the data from the studied period, the highest average intensity rate of echinococcosis was recorded in the Alai district at 40.8 per 100,000 populations, while in other districts like Kara-Kulzhinsky and Chon-Alai, the rates were 26.1, indicating a significant spread of this parasitic disease.

The Kara-Kulzhinsky district demonstrates an unfavorable epizootiological situation concerning both echinococcosis and alveococcosis. From 2005 to 2013, the incidence of echinococcosis increased more than threefold compared to the previous twenty-year period, suggesting possible changes in ecology, socio-economic conditions, or methods of animal control and preventive measures. Furthermore, in recent years, the situation regarding alveococcosis has also deteriorated, which requires attention from local health authorities.

The Chon-Alai district also confirms worrying trends: from 2000 to 2022, the total number of echinococcosis cases recorded in surgical hospitals indicates a significant frequency of the disease. The increase in the intensity rate from 22.5 in 2000 to 87.0 in 2015 highlights a pronounced rise in morbidity. It is also noteworthy that cases of echinococcosis have been reported in all rural administrations of the district, emphasizing the widespread nature of the disease.

Despite the clear facts of rising morbidity, it is essential to consider that official statistical data may not reflect the real picture of the population's infestation. Incomplete or delayed seeking of medical help by patients, as well as limited diagnosis of cases, may lead to an underestimation of morbidity rates. Therefore, it is crucial to establish a system for ongoing health monitoring of the population, including active methods for identifying cases of the disease.

The results of the study indicate a significant spread of alveococcosis in the Kara-Kulzhinsky and Chon-Alai districts of the Osh region, highlighting the importance of proper monitoring and preventive measures in these areas. Since alveococcosis had not been registered until the 2000s. Foci of lesions localized in the livers of animals suggest the presence of an active epizootiological situation. The detection of alveococcal cysts in house mice in the villages of Chalma, Kyzyl-Zhar, Kashka-Suu, and Achy-Suu points to the formation of synanthropic foci of alveococcosis, which may pose a direct risk to human health through exposure to endoparasites.

It is important to note that both stray and domestic dogs can serve as definitive hosts for this parasite. This creates an additional danger for people, especially in situations where settlements are located near natural foci and local areas are actively used as summer pastures. Infection of stray dogs from wild mammals can become a source of transmission of alveococcosis to humans, confirming the need for a comprehensive approach to addressing this problem.

Laboratory studies conducted using morphological and histological methods revealed larval forms of alveococcosis in rodents, indicating their role in the epidemiological cycle of the disease. Although the detected rate of infestation (1.2%-1.6%) may seem low, the presence of the parasite in house mice in populated areas where cases of the disease have been registered clearly demonstrates the potential risk to public health.

## CONCLUSION

The analyzed data indicate an increasing problem of echinococcosis and alveococcosis incidence in the Kyrgyz Republic. These diseases, once considered rare helminthoses, have now become widespread parasitic infections, making the country endemic for these diseases. The most pronounced morbidity has been recorded in several districts of the Osh region, such as Alai, Kara-Kulzhinsky, and Chon-Alai, where intensity rates substantially exceed average values. This data emphasizes the necessity of focusing on preventive measures in the most affected areas.

A comparative analysis of morbidity in the Kara-Kulzhinsky and Chon-Alai districts highlights not only a high level of infestation but also a remarkable surge in morbidity over recent decades. In the Chon-Alai district, the intensity rate of echinococcosis has increased more than sixfold during the analyzed period, confirming the presence of serious epidemiological issues. However, it is important to note that official statistical data may underestimate the actual scale of morbidity, necessitating additional monitoring and the activation of preventive programs.

The research findings confirm the existence of active foci of alveococcosis in the populated areas of the Kara-Kulzhinsky and Chon-Alai districts of the Osh region. The detection of alveococcal cysts in the livers of house mice in the villages of Chalma, Kyzyl-Zhar, Kashka-Suu, and Achy-Suu indicates the formation of synanthropic foci of infection, posing a potential threat to local residents' health.

The results point to possible transmission pathways of the infection from wild animals to domestic stray and household dogs, which creates a risk of environmental contamination and human infection. The epidemiological situation in these areas remains unfavorable, especially in rural settlements, where the use of natural pastures facilitates further spread of the infection.

Statistical analysis shows that the Kara-Kulzhinsky and Chon-Alai districts are at the forefront of the spread of both alveococcosis and echinococcosis in the Osh region. These facts underline the necessity for intensified monitoring aimed at controlling and preventing these parasitic diseases.

Laboratory studies have revealed larval forms of alveococcosis in house mice and common voles, confirming the presence of the parasite in the ecosystem and its potential for transmission through food chains. Despite the relatively low rate of infestation in rodents, this situation warrants attention, as forest and rural ecosystems may serve as reservoirs for infection spread.

Thus, the study's results emphasize the need for a comprehensive approach to combating echinococcosis and alveococcosis, including active public education, improved sanitary conditions, health monitoring of animals, and timely treatment of diseases. Given the current situation, it is essential to develop and implement effective strategies to reduce morbidity and improve the health of the population in the affected regions of the Kyrgyz Republic.

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## AUTHOR CONTRIBUTIONS

Raimkulov K.M. – the initiator of the research, responsible for developing the concept of the article, analyzing data, and writing the main sections of the text. Toigombaeva V.S. – collected data, conducted statistical analysis, and prepared illustrative materials for the article. Kuttubaev O.T. – involved in editing the text, ensuring compliance with scientific standards, and responsible for discussing the scientific conclusions.

## ADDITIONAL INFORMATION

(including conflict of interest statement).

## ETHICAL STATEMENT

The authors assert that all procedures contributing to this work comply with the ethical standards of relevant national and institutional guidelines, and ethical approval for the study was obtained from the Ethics Committee of the Scientific and Production Association "Preventive Medicine" of the Ministry of Health of the Kyrgyz Republic (extract from protocol No. 1 dated February 19, 2010).

## CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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